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Planning Guide

SAP Applications with AIX Live Update

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Edition Notice and Version Information

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Focus: AIX Live Update for SAP production systems
Target:
- AIX Release 7.2 technology level 3, and higher
- SAP products based on ABAP stack, e.g. NetWeaver 7.5

Doc Version	Changes
1.0	Initial Publication
1.1	Update, adding large scaling tests, and additional insights.

Preface

Running SAP on IBM POWER systems offers customers a consistent platform for their applications, best-in-class performance, resilience for critical workloads, and the most flexible infrastructure. This holds for existing IT assets, like servers and storage, as well as skills and operation procedures.

One of the features offered by the IBM AIX platform from AIX release 7.2 on is the Live Update ability, i.e. to update to a higher AIX technology level or service pack without a reboot.

In this project, the AIX Live Update feature was successfully validated on SAP systems.

The scope of this validation included small to medium sized SAP systems with ABAP stack. Any issues found during testing were investigated and resolved. They are all documented in this paper together with a set of best practices collected during the project.

Later on, large sized SAP systems with ABAP stack were added, successfully tested, and best practices were documented.

About This Document

This document is intended for architects and specialists planning to use AIX Live Update for their SAP databases and application servers to minimize planned downtime.

The most recent document version can be downloaded from IBM TechDocs: https://www.ibm.com/support/pages/sap-applications-aix-live-update

Feel free to provide feedback and change requests for this document by email at enable.SAP@de.ibm.com.

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Table of Contents

Figures

Tables

Introduction

The AIX Live Update feature allows to upgrade a system to a higher AIX service pack or technology level without a reboot, so that every application continues to run. Users don't experience any disruptions, besides a short freeze time that does not result in workload failures.

During the validation a multitude of scenarios were tested on two SAP installations, each comprised of an SAP *central instance* host (LPAR, logical partition) plus another host holding an *additional dialog instance*. A central instance setup means to have an SAP dialog instance plus all other required SAP components, namely the central services component and the global file system. Also, the database was installed on that host. AIX Live Update tests were run on the central instance host as well as on the additional instance host.
Later on, additional scaling tests were pursued, on a third, large SAP central instance installation.

Different loads and other conditions were set up during the test runs, and any issues found were documented and evaluated in order to provide guidance of best practices. The validation project was successful and found out that all the AIX Live Update executions succeeded when a few conditions, documented here, are ensured.

The global project team was made of two IBM teams, one located in Germany (the SAP Technical Enablement team) and the other one in the US (the Austin development labs). The Germany-based team was responsible for setting up the SAP installations and pursuing the tests. The US team worked on the roles of AIX kernel development expert and AIX Live Update architect.

SAP Systems in small- to medium-sized range

The two SAP systems used for validation were both NetWeaver installations with ABAP stack, one with an Oracle database, the other with a Db2 database. Both SAP systems were distributed ones, comprised of two hosts (LPARs[1]) each. One host was set up as the central instance with a database, central services, primary application server (PAS), and SAP's global file system (`"/sapmnt"`), and the other host had only an additional application server (AAS) installed. The SAP global file system is to be mounted on the hosts that hold additional application servers.
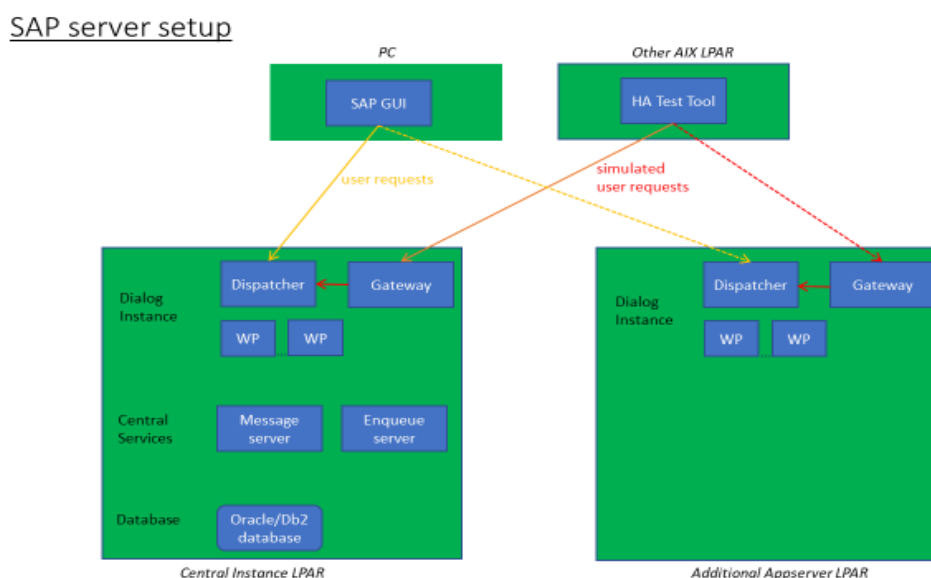
Figure 1: SAP server setup

The IBM server used to hold the LPARs for both SAP systems was an IBM Power 730 Express server (8231-E2C), with 128 GB RAM and 16 cores.

Each central instance host was configured as a shared CPU pool LPAR in uncapped mode, with SMT-4. They were sized with 6 virtual CPUs and entitled capacity of 1 CPU, with 18 GB RAM. The additional application server hosts were configured similarly, but with reduced amount of RAM of 16 GB.

The AIX version on all LPARs was release 7.2 technology level 3 service pack 1 at the start of all Live Update tests. The target version chosen during Live Update was AIX 7.2 technology level 3 service pack 2. For easier handling some of the AIX Live Update testing was pursued without actual version update, focussing on the Live Update procedures. The SAP version used on all the SAP installations was NetWeaver 7.5 with SAP kernel version 7.53 .

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[1] Logical partitions

Test scenarios for small- to medium- sized SAP systems

Conceptual approach

To obtain a representative test coverage, a wide variety of SAP scenarios on AIX had to be tested, while running some well specified sets of workload.

The variety is achieved conceptually by defining a set of relevant attributes, also called *dimensions* that can vary independently, and each one is represented by a small set of attribute values.

While some dimensions and representation points may be regarded as kind of natural and mandatory, like setting some sizing attributes to low/medium/high, other dimension's relevance is not as sharply defined. Selecting suitable dimensions, and related aspects, brings up a challenge in creating a conceptual model that represents well the reality (in this case typical customer scenarios).

Building on this model, a full *test matrix* is then defined as the *product* of all dimensions, each of them represented by some value-points per dimension. Ideally, all the elements of this matrix that represent a scenario would be tested. From a practical perspective this will not be possible for an ambitious model with many dimensions, due to the effect of *combinatoric explosion*.

Primary dimensions

Attribute "A" for the "architecture":
The variants are:
A1: Run the Live Update on the host with central instance setup, including a database installation.
A2: Run the Live Update on the host with the additional dialog instance.
Two attribute-values: A1=db_plus_appserver, A2=appserver_alone

Attribute "W" for the "workload":
Workload was generated by two means. The simplest method was to use the SAP transaction *SGEN,* which compiles ABAP source objects into binary form, and which will be stored in the database. When using SGEN to recompile all existing objects, a significant load can be produced on the LPAR.

The other method was to use the *SAP High Availability Test Tool* (Release 2.14)[2], also called *HA Test Tool,* to create SAP workload. It offers various so-called test classes which are representing different SAP workloads. The name element *High Availability* refers to some abilities that support high availability testing, but it can as well be used just for workload generation.

The variants used for attribute "W" are:
W1: Small workload: Run from SAP GUI the transaction code SGEN.

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[2] https://blogs.sap.com/2016/01/28/test-tool-for-high-availability-environments/

W2: HA Test Tool generated workload, that simulates SAP user dialogs leading to high load on the database server and the application server: "hatool_DB_load". It is parameterized by the number of users/clients and others.

W3: HA Test Tool generated workload, that can produce high CPU utilization on the central instance server: "hatool_ENQ_CPU_load". It is mainly parameterized by the number of clients.

W4: HA Test Tool generated workload, that can produce high memory utilization on the central instance server: "hatool_ENQ_MEM_load". It is mainly parameterized by the number of clients. Despite its reference to the SAP enqueue server, the major memory consumption happens in the SAP work processes.

Four attribute-values: W1=sgen_load, W2=hatool_DB_load, W3=hatool_ENQ_CPU_load, W4=hatool_ENQ_MEM_load

Attribute "B" for the "blackout time extension":
The AIX Live Update procedure does implicitly involve a so-called *blackout time*, also called *blackout period*, where all memory activities are stopped, until the surrogate LPAR is ready to run. For the investigation of the effects of longer lasting blackout times an internal method was used in order to prolong it.

The variants are:
B1: Run the Live Update without modifying the blackout time.
B2: Extend the Live Update blackout time to a value of "N" minutes that impacts the behavior, likely by hitting a timeout given by the operating system or network environment. Based on system administration experiences, a good guess is that the first impact may be experienced when 1 minute is exceeded.
Two attribute-values: B1=blackout_unchanged, B2=blackout_N_minutes

Secondary dimensions
Attribute "D" for the "database":
The variants are:
D1: Using the Oracle-based SAP installation
D2: Using the Db2-based SAP installation

Test matrices
The "core tests", with the most dense test matrix, were pursued on the SAP installation with the Oracle database. A reason for selecting this installation as the most essential, was the interest and cooperation of one customer in this project, with mainly Oracle-based SAP installations available.

Test period 1: Core testing (Oracle database)
The test matrix is shown below.
It is comprised by the primary dimensions "A * W * B":
Two architectural variants were specified as A1 (db_plus_appserver, "2-tier") and A2 (appserver_alone, "3-tier"). Four Workload variants were used, one generated from SAP GUI "SGEN" transaction, and the other three generated from HA Test Tool. For the blackout period two variants were selected: one with unchanged blackout time (usually less than a minute) and the other with blackout time extended by one minute. This

altogether resulted in 2 * 4 * 2 = 16 test cases.

Secondary dimensions:
The following secondary dimensions are of fixed values here: Database: D=oracle

Test ID	A/architecture	W/workload	B/blackout	D=oracle
A1W1B1core	db_plus_appserver	sgen_load	blackout_unchanged	x
A1W2B1core	db_plus_appserver	hatool_DB_load	blackout_unchanged	x
A1W3B1core	db_plus_appserver	hatool_ENQ_CPU_load	blackout_unchanged	x
A1W4B1core	db_plus_appserver	hatool_ENQ_MEM_load	blackout_unchanged	x
A2W1B1core	appserver_alone	sgen_load	blackout_unchanged	x
A2W2B1core	appserver_alone	hatool_DB_load	blackout_unchanged	x
A2W3B1core	appserver_alone	hatool_ENQ_CPU_load	blackout_unchanged	x
A2W4B1core	appserver_alone	hatool_ENQ_MEM_load	blackout_unchanged	x
A1W1B2core	db_plus_appserver	sgen_load	blackout_N_minutes	x
A1W2B2core	db_plus_appserver	hatool_DB_load	blackout_N_minutes	x
A1W3B2core	db_plus_appserver	hatool_ENQ_CPU_load	blackout_N_minutes	x
A1W4B2core	db_plus_appserver	hatool_ENQ_MEM_load	blackout_N_minutes	x
A2W1B2core	appserver_alone	sgen_load	blackout_N_minutes	x
A2W2B2core	appserver_alone	hatool_DB_load	blackout_N_minutes	x
A2W3B2core	appserver_alone	hatool_ENQ_CPU_load	blackout_N_minutes	x
A2W4B2core	appserver_alone	hatool_ENQ_MEM_load	blackout_N_minutes	x

Table 1: Test matrix for the SAP Oracle installation

Test period 2: Db2 testing
The secondary dimension is changed to: database D=db2.
A sub-selection of the full matrix "A * W * B" was specified as test matrix.

Test ID	A/architecture	W/workload	B/blackout	D=db2
A1**W1**B1db2	db_plus_appserver	sgen_load	blackout_unchanged	x
A2**W2**B1db2	appserver_alone	hatool_DB_load	blackout_unchanged	x
A1**W3**B1db2	db_plus_appserver	hatool_ENQ_CPU_load	blackout_unchanged	x
A2**W4**B1db2	appserver_alone	hatool_ENQ_MEM_load	blackout_unchanged	x
A1W1**B2**db2	db_plus_appserver	sgen_load	blackout_N_minutes	x

Table 2: Test set for the SAP Db2 installation

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Test variants
Please note that most of the test cases were executed not only once but multiple times, with varied parameter changes, especially when issues were found and required to be drilled down. The variations could be about increasing trace levels, or setting parameters on HA Test Tool level, SAP level or OS level for better understanding.

Preparations for AIX Live Update

Before running an AIX Live Update some preparations are required, e.g. some resources must be provided, and the rootvg volume group should be backed up. This is outlined in the following.

Resource requirements
Some resource demands must be fulfilled before running a Live Update on an AIX LPAR, respectively on the IBM POWER server holding it. The IBM Documentation is to be found here:
www.ibm.com/docs/en/aix/7.2?topic=planning-configuring-resources-live-update

Double Resources
The IBM physical server must have the available memory and processor resources equivalent to the Original LPAR profile. This is required since the Surrogate LPAR is a clone of the Original LPAR and its profile; this can be viewed as required memory and processors are doubled. The Live Update operation will decommission the Original LPAR and its resources will be given back.

The processor demand might be reduced, when specifying an option "cpu_reduction = yes" in the configuration file lvupdate.data (see below). Please note that the processes on the LPAR must be able to cope with the reduced number of CPUs for a given time, until Live Update finished. The scaling tests make extensive use of that feature, see "Test scenarios for huge-sized SAP systems".

Additional Physical Volumes
Additional physical volumes with the same size as the rootvg are required. If rootvg is comprised of <number> physical volume(s), then 2 x <number> physical volume(s) are required. This discussion will assume rootvg is contained to one physical volume and 2 additional physical volumes are required.

Best practice recommendation
In addition to the required 2 physical volumes, an optional 3rd physical volume may be employed to ease Live Update administration and avoid future edits of Live Update's configuration file. An additional disk should be seen as only minor added cost and complexity. See "Multiple Live Updates without a reboot" for details.

Example disk and volume group setup

```
root@XXXXXX/# lspv
hdisk0          00f86d3f3ea81468                rootvg          active
hdisk1          00f86d3fd4371009                None
hdisk2          00f86d3fd4371080                None
hdisk3          00f86d3fd43710fc                None
hdisk4          00f86d3fd4371182                sap_vg          active
root@XXXXXX/# getconf DISK_SIZE /dev/hdisk0
40960
root@XXXXXX/# getconf DISK_SIZE /dev/hdisk1
40960
root@XXXXXX/# getconf DISK_SIZE /dev/hdisk2
40960
root@XXXXXX/# getconf DISK_SIZE /dev/hdisk3
40960
root@XXXXXX/# getconf DISK_SIZE /dev/hdisk4
133120
```

Here the `rootvg` has a size of 40 GB, provided by `hdisk0`. The SAP application is contained in the volume group `sap_vg` with size of 130 GB, provided by `hdisk4`. The additional disks `hdisk1`, `hdisk2`, `hdisk3` are used for AIX Live Update.

General preparations

Besides the resource demands to fulfill, also some generic preconditions should be checked, and precautions considered.

- If an AIX Live Update is to be run for the first time, make sure to study the IBM Documentation: www.ibm.com/docs/en/aix/7.2?topic=updates-live-update

- Focus on the section "Planning", including advice for "LPAR requirements for Live Update", "Live Update restrictions", and "Best practices for the Live Update function".

- In the SAP context, also study the best practices of this whitepaper document.

- Back up the `rootvg` of the AIX LPAR and consider, to back up the LPAR profiles defined on the Hardware Management Console (HMC), that manages the LPAR to be updated.

- HMC access, by default HMC `hscroot` works with Live Update. Alternatively, HMC allows a user to have a task role of `hmcclientliveupdate` and resource role of `AllSystemResources` to work with Live Update.

- Before doing the Live Update, do a prerequisite check provided by `geninstall` tool, and handle any reported issue:

```
hmcauth -a <hmchost> -u <hmcuser> -p <hmcpassword>
geninstall -k -p
```

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Configuration of the file lvupdate.data

A configuration file `/var/adm/ras/liveupdate/lvupdate.data` needs to be filled with the specification of the planned AIX Live Update run. It can be created as a copy of `/var/adm/ras/liveupdate/lvupdate.template` and then modified appropriately. The template file contains detailed parameter descriptions. The following web link shows the newest update of the parameters and descriptions:
www.ibm.com/docs/en/aix/7.2?topic=planning-configuring-resources-live-update

At the very minimum, two hard disks are to be specified which will contain clones of the `rootvg`, and the IP address of a Hardware Management Console, and a user to access it.

```
disks:
        nhdisk  = hdisk1
        mhdisk  = hdisk2
        tohdisk =
        tshdisk =

hmc:
        lpar_id =
        management_console = XX.XX.XX.XXX
        user = hscroot
```

Multiple Live Updates without a reboot

Attempting to execute a second Live Update with the same specification for `nhdisk` will result in a failure because `nhdisk` is still in use. This is used as the new or cloned Surrogate disk during Live Update and will be unavailable for other use until the next successful Live Update or a reboot. It will be part of a special volume group called `lvup_rootvg`. In order to execute another Live Update, another disk or several disks must be specified for `nhdisk` in the `lvupdate.data` file. After the second Live Update, the original `nhdisk` will no longer be in use and is therefore available for another Live Update.

In order to avoid having to switch the value of `nhdisk` in the `lvupdate.data` file for each Live Update, it's possible to specify both `nhdisk` and `alt_nhdisk`. If `nhdisk` is not available, Live Update will use `alt_nhdisk`. In this way, by specifying `mhdisk`, `nhdisk`, and `alt_nhdisk`, any number of Live Updates can be performed without needing to update the `lvupdate.data` file each time.

The extended configuration for multiple live updates is recommended here. It could look as follows:

```
disks:
        nhdisk     = hdisk1
        mhdisk     = hdisk2
        alt_nhdisk = hdisk3
        tohdisk =
        tshdisk =

hmc:
        lpar_id =
        management_console = XX.XX.XX.XXX
        user = hscroot
```

Example of AIX Live Update run: Small- to medium-sized SAP systems

The AIX Live Update run described on the following pages was selected as a representative example. In this scenario, the SAP High Availability Test Tool was used to create an SAP workload. After starting the program, three phases can be distinguished:
1. Initialization
2. High load phase
3. Post-processing, i.e. creation of output data like log files and summaries

The working method of the tool can be roughly described as follows: the tool simulates a configurable number of clients through threads during the high load phase. Each client thread processes the following sequence of calls in a loop:
1. Login
2. Execute steps 1 – n
3. Logoff

The SAP HA Test Tool offers various so-called test classes which are representing different SAP workloads. The test class CL_HA_DB_LOAD was chosen for the sample AIX Live Update run. The selected test class puts load on the database and is customized as shown below:
- *clientnum = 50:*	*number of simulated client users*
- *stepnum = 5:*	*number of steps per loop i.e. insert + update + delete + rollback + check*
- *duration = 1800:*	*duration in seconds of high load phase of the test run*

Two AIX LPARs were used to run the test. The first AIX LPAR hosted an Oracle database and an SAP application server. The AIX Live Update run took place on this LPAR and covered a migration from AIX operating system level 7200-03-01-1838 to 7200-03-02-1846. At the same time the SAP High Availability Test Tool was started on the other AIX LPAR simulating clients who are logging on to the SAP application server on the first AIX LPAR. This setting has the Test ID A1W2B1core as described in "Table 1: Test matrix for

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the SAP Oracle installation". Below are the steps for performing the AIX Live Update run:

1. At the beginning the AIX system level is 7200-03-01-1838. The user root authenticates with the HMC using the hmcauth command. This is a precondition to run AIX Live Update.

```
(0)root @ xxxx01: /
# oslevel -s
7200-03-01-1838

(0) root @ xxxx01: /
# hmcauth -a x.x.x.x -u hscroot -p xxxxxxxx
```

2. The geninstall command initiates the AIX Live Update run as well as the migration to service pack 7200-03-02-1846 which is located in /mnt/update_all (the date command is used as an easy way to get a timestamp at the start and the end of the test).

```
(0)root @ xxxx01: /
# date; geninstall -k -d /mnt update_all; date
Sun Aug 16 04:21:34 CDT 2020

Validating live update input data.

Computing the estimated time for the live update operation:
---------------------------------------------------------
LPAR: xxxx01.x.x.x.x
Blackout time(in seconds): 122
Total operation time(in seconds): 1074

Checking mirror vg device size:
-------------------------------------------
Required device size: 24320 MB
Given device size: 40959 MB
PASSED: device size is sufficient.
…

PASSED: Managed System state is operating.
INFO: Any system dumps present in the current dump logical volumes will
not be available after live update is complete.

Non-interruptable live update operation begins in 10 seconds.
Initializing live update on original LPAR.

Validating original LPAR environment.

Beginning live update operation on original LPAR.
…

        Blackout Time started.

        Blackout Time end.

Workload is running on surrogate LPAR.
.................................................................................
.............................................
Shutting down the Original LPAR.
............................
The live update operation succeeded.
…

Sun Aug 16 04:53:45 CDT 2020
(0) root @ xxxx01: /
```

3. When the AIX Live Update run is finished, the AIX operating system level is 7200-03-02-1846. The actual duration of the blackout time shown by the alog command ("alog -t mobte -o") is 41.079693 seconds compared to the estimated duration of 122 seconds.

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```
(0) root @ xxxx01: /
# oslevel -s
7200-03-02-1846

(0) root @ xxxx01: /# alog -t mobte -o | tail -1
time=081620:04:53:32 pid=23363239110770689 type=Global
...
stdl_blackout=78.000000s stdl_global=1392.000000s blackout=41.079693s
global=1215.240479s
```

The `alog` command shows the time values `stdl_blackout` and `stdl_global`, telling estimates for blackout period and overall Live Update time, and `blackout` and `global` telling actual used times for the same. Please note that the following table shows a longer Live Update time, since it also encompasses the Service Pack upgrade time.

Date		Started	Finished	Time (hh:mm:ss)
August 16, 2020	AIX Live Update	04:21:34	04:53:45	00:32:11
	SAP HA Test Tool	04:21:45	04:53:42	00:32:00
	Blackout time	04:46:45	04:47:26	00:00:41

Table 3: Measured runtimes with medium load (test case A1W2B1core)

The SAP High Availability Test Tool provides a graphical view of the test result (`loadtest.html`). In the given scenario it looks like shown below. The selected example shows a typical behavior seen during the tests: SAP's High Availability Test Tool is facing long response times and the transactions of the simulated users are paused during the blackout period, but they continue after the blackout time ends and the tool completes normally. An abnormal termination of the test tool run is not detected.

Summary of Test Run with ID: 20200816042145
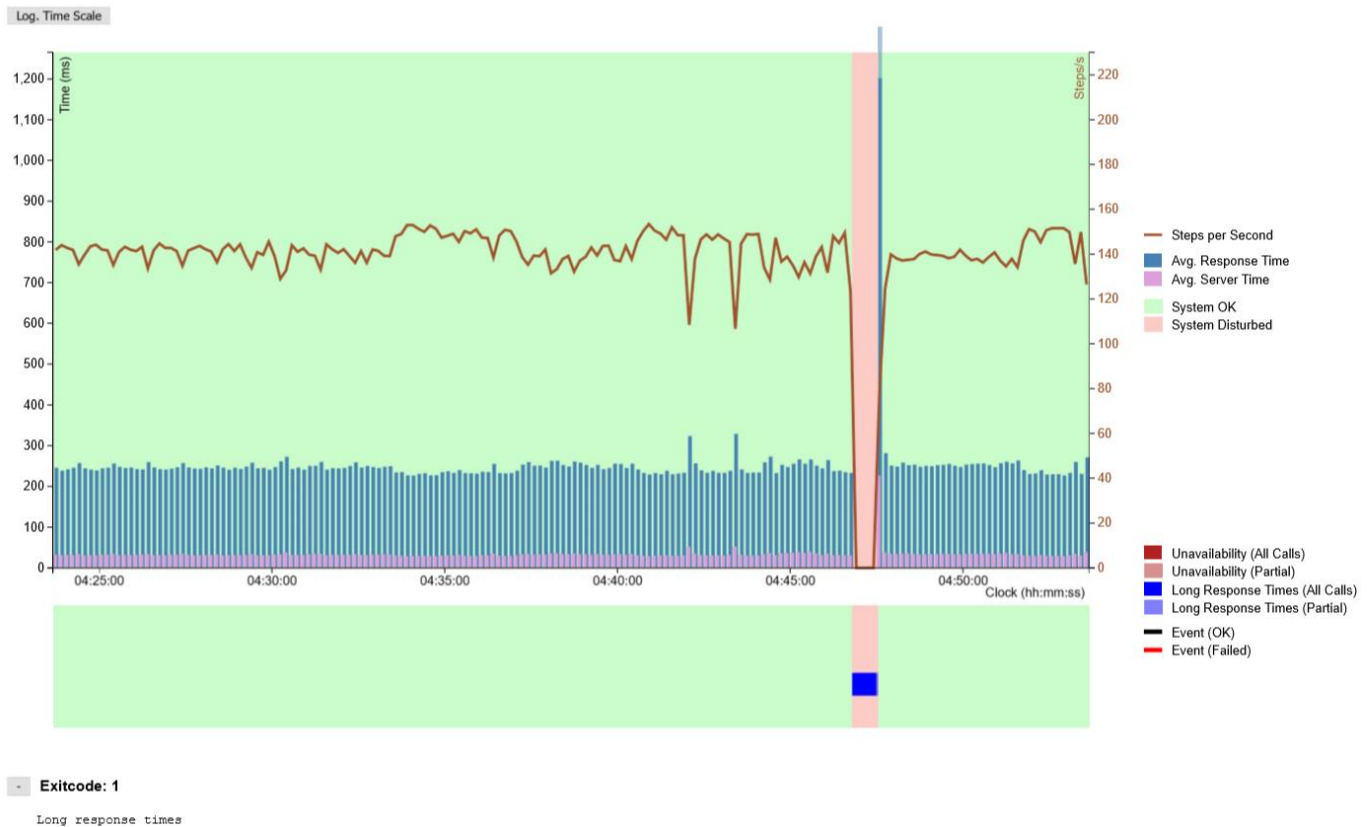
Figure 2: Summary of HA Test Tool run, with medium-sized SAP system

The summary has the following structure:

Header: ID of test run

Chart: Depicts the high load phase of the test run

- Light green background: system ok
- Light red background: system disturbed (periods of unavailability or long response times occurred)
- Upper part
    o Steps per second
    o Average response and server time
    o Logarithmic time scale offered if response time exceeds the linear time scale
- Lower part
    o Displayed if the system was disturbed for some time or if events were executed
    o Periods of unavailability & periods of long response times
    o Events
- Additional information
- Exit code

Test scenarios for huge-sized SAP systems

Conceptual approach

The idea of testing against a huge SAP system, i. e. of scaling tests, is to stress the Live Update mechanism by applying it against an SAP system with CPU intense or memory intense workload.

An important difference with the previous tests with small and medium workload is about temporary CPU resources. Per default Live Update requires that the physical server where the LPAR to be updated resides on can temporarily provide the same amount of CPU and memory resources as configured on the LPAR. That was ensured in the previous tests. For the scaling tests that is still required for the memory resources, since there is no other way.

For the CPU resources in the scaling tests a feature of Live Update called *CPU reduction* was utilized, to be specified in the Live Update configuration file `lvupdate.data`, described there in the template's comments section. That feature will lead to using only the LPAR's configured CPU resources, to be distributed during the Live Update procedures between the Original LPAR, and another newly created one, called Surrogate LPAR. At the end all CPUs will be moved to the Surrogate and the Original LPAR will be removed.

The `lvupdate.data` configuration file used during scaling tests looked as follows.

```
general:
    cpu_reduction = yes

disks:
    nhdisk   = hdisk3
    alt_nhdisk = hdisk4
    mhdisk   = hdisk5

hmc:
    management_console = XX.XX.XX.XXX
    user = XXX
```

The "X" fields held some actual values. For some investigative tests, additional options "kext_check" and "trc_option" were used, both described in the configuration file template's comments.

Scaling Test setup

The tests were run in an SAP system "QO3" with an Oracle database. It was set up as "Central Instance", i.e. the database and the application server residing on the same LPAR. The LPAR was configured as shared CPU pool LPAR in uncapped mode, with SMT-8. It was sized with 50 virtual CPUs, and entitled capacity also 50 CPUs, with 200 GB memory, on an IBM server E980 based on POWER9 architecture. SAP was configured with 100 work processes, and a maximum memory utilization of 140 GB. The installed SAP product was

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NetWeaver 7.5 ABAP application server, with a database Oracle 12.1.0.2, on AIX version 7.2 TL3 SP1. The setup was structurally analog as in the small- to medium-sized szenario ("Figure 2: Summary of HA Test Tool run, with medium-sized SAP system"), the only difference was an "additional application server" in the previous setup.

To produce significant CPU utilization or memory footprint the SAP HATool was used and installed on another AIX LPAR. It simulated many active SAP users (about 50 or 100), connecting in parallel to the SAP LPAR and issuing requests to be handled by the work processes. The SAP HATool version installed was 2.14. Two further test classes "ENQ_CPU" and "ENQ_MEM", also written by SAP, have been added and suitable for producing high CPU load respective high memory footprint against the SAP work processes.

Three test categories

The tests were run in three phases.
- First some basic tests with idle SAP, as well as medium load generated via SAP internal transaction "SGEN".
- In the second phase the CPU scaling tests.
- In the third phase the memory scaling tests.

Basic scaling tests

Already the idle load SAP scenario showed a memory footprint of 65 GB, as summed consumption of all processes and the AIX itself. Some Live Update tests were run first in relaxed load scenarios, against an idle SAP system, and against some medium load situation generated by the SAP internal transaction "SGEN", yet without involvement of the HATool.

The CPU distribution between Original and Surrogate LPAR during the Live Update procedure was determined by utilizing the LPAR profile's configuration value "minimum processing units" (also called "minimum capacity"). It was parametrized here between the two values 2.5[3] and 25, to reflect both a very uneven and a very even distribution.

All these tests were meant as preliminary, to get a basic understanding of the system setup and its reactions under relaxed testing conditions.

CPU scaling tests

The tests were run while CPU load was produced by the SAP HATool with the "ENQ_CPU" test class, simulating 25 users as a lower load and 100 users as a higher load. These "synthetical users" were configured to produce a nearly continuous load, capable of utilizing all the available CPU resources. For both the lower load and higher load situation

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[3] That is the smallest reasonable value to determine an entitled capacity, as per constraint "entitled capacity / online virtual CPUs >= 0.05" that holds for any LPAR profiles

the minimum capacity value was parametrized between 2.5 (most unequal distribution) and 25 (most equal distribution).

Load type	HATool load parametrization	LPAR minimum capacity
HATool(ENQ_CPU)	low load: 25 synthetical SAP users (numclients = 25)	25
HATool(ENQ_CPU)	low load: 25 synthetical SAP users	2.5
HATool(ENQ_CPU)	high load: 100 synthetical SAP users	25
HATool(ENQ_CPU)	high load: 100 synthetical SAP users	2.5

Table 4: CPU scaling tests

As an overall observation, the Live Update procedure seemed to be put here under effective stress, revealing some Live Update issues, mostly minor ones. All issues were resolved, and tests run successfully. Documentation is given in the chapter "Best practices and issues found".

Memory scaling tests

These tests were run with the HATool utilizing the "ENQ_MEM" test class, issuing requests to the SAP work processes allocating and deallocating some specified amounts of memory, and at the same time not leading to high CPU utilization. The main relevant parametrization here turned out to be the amount of memory to be allocated, and not so much the number of simulated users. The latter was set to 100 which is the maximum number that can be handled by the SAP work processes in real parallel fashion. The LPAR parameter for minimum capacity is documented for completeness but didn't influence this kind of test, and set to the equal balanced value of 25.

Load type	HATool load parametrization	LPAR minimum capacity
HATool(ENQ_MEM)	Low footprint: 100 users, 100 MB-per-step	25
HATool(ENQ_MEM)	High footprint (SAP memory utilization near to maximum): 100 users, 750 MB-per-step	25

Table 5: Memory scaling tests

Example of AIX Live Update run: Huge-sized SAP systems

The following example describes an AIX Live Update run where the SAP High Availability Test Tool is used to create an SAP workload, similar to the small- to medium-sized example ("Example of AIX Live Update run: Small- to medium-sized SAP systems"). The working method of the HATool is already explained there.

The goal of this test is to use the CPUs to full capacity and so the test class CL_HA_ENQ_CPU_USAGE is selected which is designed to utilize the CPUs. It allows to specify

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the number of internal loops done by a single step with the parameter LoopsPerStep.

The test class was configured as follows:
- *clientnum = 100:*   *number of simulated client users*
- *stepnum = 5:*   *number of steps between login and logout*
- *LoopsPerStep = 200:*   *number of internal loop per step*
- *duration = 4800:*   *duration in seconds of high load phase of the test run*

The screen shot below shows in its column pc (for processors consumed) that the CPU utilization increased almost up to 50 CPUs after the HATool have been started at 07:15:03 AM CEST.

```
[root@xxxx02] /home/root
#vmstat -wIt 2

System configuration: lcpu=400 mem=205056MB ent=50.00

   kthr            memory                          page                              faults                    cpu              time
----------- -------------------- ------------------------------------- ------------------ ---------------------- --------
  r   b  p        avm       fre   fi    fo    pi   po    fr    sr     in     sy     cs us sy id wa    pc     ec hr mi se
  5   0  0   17598986  25873414    0    72     0    0     0     0    194  92687  2332  0  0 99  0  1.09   2.2 07:15:08
  4   0  0   17602028  25870350    9    43     0    0     0     0    208  50166  2066  1  0 99  0  1.01   2.0 07:15:10
 25   0  0   17611294  25861001    7    34     0    0     0     0    157  44795  1696  2  0 98  0  2.22   4.4 07:15:12
 44   0  1   17624250  25847944   21   190     0    0     0     0    239  71263  2199  3  0 96  0  3.23   6.5 07:15:14
 59   0  0   17636380  25834136   26  1650     0    0     0     0    330  79245  3380  8  0 92  0  6.57  13.1 07:15:16
 70   0  0   17643699  25826876   47   820     0    0     0     0    284 101432  3298 14  0 86  0 10.62  21.2 07:15:18
 84   1  0   17651226  25819302   69   919     0    0     0     0    408 104971  4050 20  0 80  0 14.62  29.2 07:15:20
 85   1  0   17653035  25815202   82  1975     0    0     0     0    514  40355  5712 23  0 76  0 18.49  37.0 07:15:22
 83   1  0   17651397  25817370  102  2231     0    0     0     0    598 365984  4797 27  0 73  0 22.04  44.1 07:15:24
 84   1  0   17652795  25815582  122   431     0    0     0     0    559 159571  6620 31  1 68  0 26.43  52.9 07:15:26
 84   1  0   17653569  25814869  178   384     0    0     0     0    685  79201  7056 34  0 65  0 30.25  60.5 07:15:28
 80   1  0   17655881  25812465  216   311     0    0     0     0    861  44910  7931 40  0 59  0 34.23  68.5 07:15:30
 82   0  0   17659928  25808200  235  1080     0    0     0     0   1023 153343  7999 43  0 56  0 37.52  75.0 07:15:32
 83   1  0   17661233  25804225  223  2116     0    0     0     0   1121 176478  7669 46  0 54  0 41.30  82.6 07:15:34
 80   0  0   17663533  25801001  276  4890     0    0     0     0   1190  45602  9552 47  0 53  0 44.91  89.8 07:15:36
 82   0  0   17666336  25798246  253  1018     0    0     0     0   1112 221088  8789 48  0 52  0 47.61  95.2 07:15:38
 81   0  0   17666727  25797588  281  1472     0    0     0     0   1124 598826  8719 49  0 50  0 48.11  96.2 07:15:40
 81   0  0   17667761  25796219  270   427     0    0     0     0   1125  56748  9400 49  0 51  0 48.49  97.0 07:15:42
 83   0  0   17669868  25794117  277   600     0    0     0     0   1166 121108  9256 48  0 51  0 48.59  97.2 07:15:44
```

Like before, two AIX LPARs are used to run the test. The AIX Live Update run is executed on the first AIX LPAR which hosted an Oracle database and an SAP application server and the HATool was started on the second LPAR. Again, a migration of the AIX operating system level from 7200-03-01-1838 to 7200-03-02-1846 has been performed.

The various steps in detail:
1. System level is 7200-03-01-1838 before the AIX Live Update. As usual user root user authenticates with the HMC using the hmcauth command.

```
[root@xxxx02] /home/root
#oslevel -s
7200-03-01-1838

([root@xxxx02] /home/root
#hmcauth -a x.x.x.x -u luvalid3 -p xxxxxxxx
```

2. The geninstall command combines both: The start of the AIX Live Update run and the migration to service pack 7200-03-02-1846 which is located in /tmp/7200-03-02-1846/ppc update_all (the date command is used to get a timestamp at the start and the end of the test).

```
[root@xxxx02] /home/root
#date; geninstall -k -d tmp/7200-03-02-1846/ppc update_all; date
Tue Mar 30 07:10:03 CEST 2021

Validating live update input data.

Computing the estimated time for the live update operation:
-----------------------------------------------------------
LPAR: xxxx01.x.x.x.x
Blackout time(in seconds): 515
Total operation time(in seconds): 2217

Checking mirror vg device size:
-------------------------------------------
Required device size: 50816 MB
Given device size: 51199 MB
PASSED: device size is sufficient.
…

PASSED: Managed System state is operating.
INFO: Any system dumps present in the current dump logical volumes will
not be available after live update is complete.

Non-interruptable live update operation begins in 10 seconds.
Initializing live update on original LPAR.

Validating original LPAR environment.

Beginning live update operation on original LPAR.
…

        Blackout Time started.

        Blackout Time end.

Workload is running on surrogate LPAR.
.....................................................................
.........................................
Shutting down the Original LPAR.
...........................
The live update operation succeeded.
…

Tue Mar 30 08:39:05 CEST 2021
[root@xxxx02] /home/root
```

3. After the AIX Live Update run is finished, the AIX operating system level is 7200-03-02-1846. The recorded duration of the blackout time and the overall runtime has exceeded the estimates by far:

	estimate	actual
Total operation time	2217 sec	4829 sec
Blackout time	515 sec	951 sec

This is a known side effect, mostly due to the use of CPU reduction. AIX Live Update is currently not able to provide a more accurate estimate when using CPU reduction.

```
[root@xxxx02] /home/root
#oslevel -s
7200-03-02-1846
[root@xxxx02] /home/root
#alog -t mobte -o | tail -1
time=033021:08:38:56 pid=133137990401654785 type=Global
...
stdl_blackout=201.000000s stdl_global=3290.000000s blackout=950.814514s
global=4829.360840s
```

Date		Started	Finished	Time (hh:mm:ss)
March 30, 2021	AIX Live Update	07:10:03	08:39:02	01:28:59
	SAP HA Test Tool	07:15:03	08:35:48	01:20:45
	Blackout time	07:37:54	07:53:45	00:15:51

Table 6: Measured runtimes with huge CPU load

As shown in "Figure 3: Summary of HA Test Tool run, with huge sized SAP system" the HATool's graphical view exhibited still a typical pattern. The blackout time is significantly longer compared to the test that was performed on the small to medium system.
Note: IBM AIX development created APAR IJ32476 which further reduces the blackout time by about 50% according to our observations. That improvement will be included in AIX 7.2 TL5 SP3 and in the upcoming AIX 7.3 release.

During the blackout time the SAP application server became unavailable for the simulated users. After the blackout time has ended the simulated users of the HATool continued with their work and the HATool was completed normally.
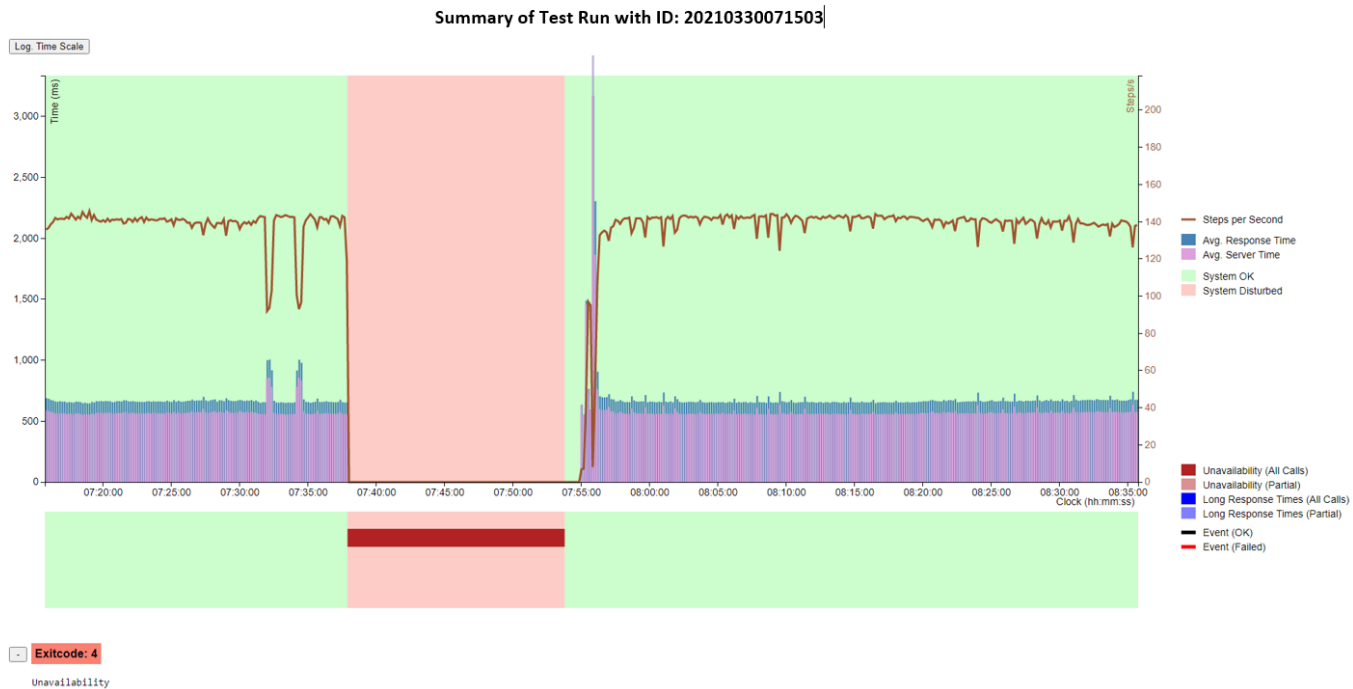
Summary of Test Run with ID: 20210330071503

Figure 3: Summary of HA Test Tool run, with huge sized SAP system

The structure of the summary has already been described at "Figure 2: Summary of HA Test Tool run, with medium-sized SAP system" and is also applicable for the above chart.

Best practices and issues found

The issues found during test cases are documented in this paper. All of them were evaluated until they were understood, and the best practices concluded, so that they could be avoided. A few issues were already known at the beginning of the project, from an earlier evaluation, and also documented here.

Tape devices

Tape devices are not supported for AIX Live Update on AIX 7.2 TL3 where this testing was done. The precondition check via "`geninstall -k -p`" shows following message if tape devices exist on the current LPAR: "`1430-011 FAILED: local tape devices are not supported.`"
AIX 7.2 TL5 includes support for systems with IBM Spectrum Protect LAN-free backup to N_Port ID Virtualization (NPIV) connected tape devices. More details can be found here: www.ibm.com/docs/en/aix/7.2?topic=planning-restrictions.

Lightweight memory trace

In some scenarios the Live Update prerequisite check issued the following:
"`1430-036 FAILED: Not enough available space for /var to dump Light weight memory Trace buffers.`"

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Live Update LMT buffer size potential miscalculation is fixed with APAR IJ30123, included in AIX 7.2 Technology Level 5 Service Pack 2 (TL5 SP2).

Check if enough free space is available in the `/var` file system.

LMT size calculation comes from tunable `raso` parameters:
`(mtrc_commonbufsize + mtrc_rarebufsize) * 4096 * lcpus`

IPSEC

A known restriction is that the feature *IPSEC* must be deactivated during AIX Live Update. The Live Update precondition check would show following:
"1430-202 FAILED: Live update cannot run when there is active ipsec configuration."

In SAP scenarios IPSEC may be used for SAP Clones. In that use case the IPSEC feature is only required on the SAP Clone system as long as it is active.

No NFS based executables and shared libraries

A restriction for Live Update is there cannot be NFS-mounted executables and shared libraries running during a Live Update operation.

In the SAP context the `/sapmnt` file system is the critical element here. In typical SAP installations this directory is NFS mounted onto all hosts with SAP instances of an SAP system, besides on the host where the central instance is running.
Per SAP default installation the SAP executables are copied from the `/sapmnt` tree to a local directory and started from there ("sapcpe" mechanism).

Recommendation:
In the SAP context, it should be checked before Live Update, whether any processes are loaded from NFS-based executables, especially for the executables located on the `/sapmnt` file system.

Live Update memory demands

Live Update memory demands must be taken into account along with memory used by applications and workload which can cause excessive paging and potentially running out of paging space – an out of memory situation (OOM).
Live Update will need an estimated 2.5 MB per system thread, as a rule of thumb.

Important recommendation:
To avoid the risk of exhausting memory during Live Update, the applications and AIX must not consume more than 80% of the LPARs physical memory (RAM), so that 20% are available for Live Update operations.
Memory Usage: The command "svmon -G -O unit=MB" provides with its "available" column an accurate account of available memory. The "inuse" column can be deceiving since it includes file cache (memory usage) which is evicted for any memory demands and properly ignored by the "available" column.

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Live Update "CPU reduction" feature

Given an HMC profile and available resources it may not be possible to fulfill the demand for the same number of Original CPUs for the Surrogate LPAR. To help alleviate this scenario Live Update offers a *CPU reduction* feature. This means the ability to reduce CPUs from the Original and provide to the Surrogate given available CPUs cannot fulfill a profile's minimum CPU value . This is documented in section 1.1.6 here: www.redbooks.ibm.com/redbooks/pdfs/sg248453.pdf.
The distribution of CPUs between the Original LPAR and the Surrogate LPAR is determined by the parameter "minimum shared processing units" in the HMC profile.

Best practice recommendation:
The testing didn't show any significant difference in behavior or performance when choosing between very uneven or choosing very balanced distribution of the available CPUs. Therefore, it is recommended for ease of handling to set the "minimum shared processing units" parameter to half of the "desired shared processing units", or just to leave it at the current setting from the LPAR definition.

Checkpointing failure at high load situation

```
geninstall output:
1020-318 Failed to checkpoint LPAR 3 times. Give up now. [02.343.0337]
...
1430-115 Warning: Cleanup from the Live Update failure may not have been
successful. Run clvupdate to finish the cleanup.

Log file /var/adm/ras/liveupdate/logs/lvupdlog:
KLVUPD 1616596652 DEBUG -12780228/35062299 Failed to checkpoint the process
12780228: disp+work
KLVUPD 1616596652 DEBUG -12780228/35062299 (pid/tid/iar:
12780228/35062299/F510) -millicode reference count must be null if
architecture-dependent millicode on new kernel has changed. line: 6434,
fct: mcr_chkpnt_safe, rc: 11
...
1020-319 LPAR temporarily not checkpointable. Retrying in 3 seconds.
...
1020-318 Failed to checkpoint LPAR 3 times. Give up now. [02.343.0337]
```

Impact: Live Update fails, and operation remains on the Original LPAR.

The update from AIX 7.2 TL3 SP1 to TL3 SP2 includes a change to low level, highly optimized code called millicode. When there are updates on this code, Live Update detects them and applies more stringent criteria when checkpointing processes. With the highly scaled memory test, Live Update was unable to checkpoint the processes. This is a limitation of Live Update that might be removed in a future version of AIX.

Recommendation: Rerun the Live Update at a time with lower load on the system.

Migration failure with status 4

Impact: Live Update fails, and operation remains on the Original LPAR.

```
geninstall output:
1020-281 The migration operation has failed on the remote node (remote
status 4). Please check the command's output on the remote node for
details. [02.343.0311]

Log file /var/adm/ras/liveupdate/logs/lvupdlog:
0516-024 lqueryvg: Unable to open physical volume.
        Either PV was not configured or could not be opened. Run
        diagnostics.
0516-1140 importvg: Unable to read the volume group descriptor area
        on specified physical volume.
```

This is a timing issue where AIX performs disk health checks and may affect Live Update operation.

It is fixed with APAR IJ26902, included in AIX 7.2 TL5.

Migration failure with status -15

```
geninstall output:
1020-281 The migration operation has failed on the remote node (remote
status -15). Please check the command's output on the remote node for
details. [02.343.0311]

Log file /var/adm/ras/liveupdate/logs/lvupdlog:
OLVUPD 02/16/2021-11:04:49.242 ERROR olvupdate.c - 1112 - omcr_monitor:
mcr exited in error with status 6
...
1020-281 The migration operation has failed on the remote node (remote
status -15). Please check the command's output on the remote node for
details. [02.343.0311]
```

Impact: Live Update fails, and operation remains on the Original LPAR.

Cluster Communications daemon (clcomd) should be stopped before Live Update and restarted after Live Update – CAA registers a script with Live Update to perform this and is not properly working.

It is fixed with APAR IJ32125, included in AIX 7.2 TL5 SP3.

Live Update completion with issues, resource match error

```
geninstall output:
1430-230 WARNING: An error occured while trying to match Surrogate's
resources (e.g. CPUs or memory) to that of the Original's. The user or
administrator may attempt to restore them manually from a management
console (e.g. HMC).
1430-094 The live update operation completed, but one or more errors
occurred during post-processing after the update was applied.

Log file /var/adm/ras/liveupdate/logs/lvupdlog:
"restore_resources: Exit rc = -1"
```

Impact: Live Update operation is successful, but proper resource restoration on the Surrogate uncertain.

The fix will make an additional check and avoid the WARNING if resources were restored to the Surrogate at Original levels. If this fix is applied or not, Live Update always checks the status of the previous Live Update. Live Update will prompt the user to run the `clvupdate` utility if any (1430-094) post processing errors need to be corrected before running Live Update again.

It is fixed with APAR IJ32063, included in AIX 7.2 TL5 SP3.

Live Update completion with issues, memory migration timeout

```
geninstall output:
1430-094 The live update operation completed, but one or more errors
occurred during post-processing after the update was applied.

Log file /var/adm/ras/liveupdate/logs/lvupdlog:
"MCR time-out after 3600 seconds"
```

Impact: Live Update operation is successful.

1430-094 is a generic error message and in this use case, triggered by MCR time-out.

An internal timeout has been exceeded. This is fixed with APAR IJ31542, contained in AIX 7.2 TL5 SP3.

SAP Syslog messages

The SAP System Log, with transaction code *SM21*, may show some messages, flagged as errors, warnings, or informations, induced by the AIX Live Update.
Shown below are the kind of messages that occurred during the validation tests. They were assessed by SAP experts as uncritical.
Some messages, flagged as *RD* for "gateway reader process", are related to the SAP instances gateway process. This process is meant to receive requests from external programs outside of the SAP instance via so called *RFC* protocol, defined by SAP. The gateway process will forward valid RFC requests in an internal format to the dispatcher process which then selects a work process to handle the request.

SAP Applications with AIX Live Update

The HA Test Tool used in the testing is one example of an external program sending request to the gateway process. The errors that were found, related to the communication between HA Test Tool and gateway might also occur when other external programs are communicating with the gateway.

Usually only some of the following kind of error messages occurred during HA Test Tool usage or none at all. The number of messages can increase to a high amount, if the *blackout period* of the AIX Live Update, where both the Original LPAR and the Surrogate LPARs are frozen, is taking longer than 60 seconds.

write error

Example:

```
10:14:23 RD  Q0 I Operating system call writev failed (error no. 32 )

10:14:23 RD  S2 3 Connection to CPI-C client 273 was closed
```

Usually the "writev" error triggers the "Connection … closed" error as a follow-up message.

The AIX error code 32/EPIPE is documented as "Broken pipe".

Explanation: A keep alive request is sent from SAP gateway process to the HA Test Tool, but not answered. These keep alive messages belong to the underlying SAP RFC protocol and are assessed as uncritical.

recv error

Example:

```
10:14:23 RD  Q0 I Operating system call recv failed (error no. 73 )
The AIX error-code 73/ECONNRESET  is documented as "Connection reset by
peer".
```

Explanation: The SAP gateway process is waiting for further data from the HA Test Tool, but don't receive them. That is also assessed as being part of the keep-alive mechanism, and thus uncritical.

CPIC Communication error

A log message similar to the following appears, flagged as "warning", telling about "Communication error" and "CPIC", and always followed by two informational messages.

```
10:55:31| DIA |007         |001|HATT |         |R49        |
Communication error, CPIC return code 020, SAP return code 223
|
10:55:31| DIA |007         |001|HATT |         |R5A        |
> Conversation ID: 75869720
10:55:31|XXXXXX_A75_02|DIA |007         |001|HATT  |         |R64        |
> CPI-C function: CMSEND(SAP)
```

Explanation: This is also assessed as related to the RFC protocol used by the HA Test Tool and can be avoided or at least diminished by setting the parameter jco.cpic_pong_timeout to a value that is higher than the expected blackout period.

Buffer synchronization

10:14:23 DIA 037000SAPSYSBS 5

The buffer synchronization has not been called for 234 seconds

This is assessed as an invalidation of some SAP internal caches due to too long outstanding synchronization and seen as uncritical.

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TIME_OUT error

A log message similar to the following appears, flagged as "error", telling about a TIME_OUT having occurred, and is accompanied by an additional SAP Short dump, i.e. debug informations available via transaction code ST22.

```
08.03.2021      11:17:54    ish40036_QO3_00   DIA   060   000   SAPSYS
   @5C\Qvery high priority@     AB0   Runtime error "TIME_OUT"
occurred.
08.03.2021      11:17:55    ish40036_QO3_00   DIA   060   000   SAPSYS
   @SR\Qinformation@ AB1   > Short dump "210308 111754 ish40036_QO3_00
SAPSYS" created.
08.03.2021      11:17:55    ish40036_QO3_00   DIA   060   000   SAPSYS
   @5C\Qvery high priority@     D01   Transaction canceled 00 671 (
TIME_OUT 20210308111754ish40036_QO3_00 SAPSYS 000 )
```

Explanation:

If the corresponding work process log file (developer trace dev_w*NN*) tells that the "PXAPreload" not having finished, this whole error situation can be ignored. It is a caching mechanism to load ABAP program code from database into some SAP application server buffers (PXA, program executable area).

That mechanism has some time window set, as per parameters "rdisp/scheduler/prio_[high|normal|low]/max_runtime", usually to 10 minutes.

In the scaling test scenarios, that happened a few times, sometimes during Live Update, and sometimes after reboot and restart of SAP. It is assumed to be related to the huge size of the SAP instance. The amount of TIME_OUT errors may be mitigated by setting the mentioned parameters higher. Over all these errors seem of minor concern.

Conclusion

The AIX feature of Live Update was validated successfully on SAP systems with ABAP stack. The project experiences show that it is working well when the systems are set up according to the guidelines given in the IBM Documentation, and according to the best practices given in this paper.

Additional stress tests done on a large scale, from CPU load and memory footprint perspective, confirmed that Live Update handles even huge SAP systems, when adhering to some reasonable best practices, which are documented here.

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[4] Moved from older location https://www.youtube.com/watch?v=dHvBQOXtjaY

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